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The aquatic arthropod community of the pitcher plant, *Nepenthes bicalcarata* (*Nepenthaceae*) in Brunei

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Summary. A revised list of the metazoan inhabitants of pitchers of *Nepenthes bicalcarata* is presented. 33 species are recorded, making the community for *N. bicalcarata* the most complex known for any species of *Nepenthes*.

Nepenthes bicalcarata Hook. f. is a carnivorous pitcher plant common in the peatswamp forests of north-western Borneo. As well as trapping and digesting insects for nutritional benefit, it has been shown that the pitchers of most *Nepenthes* species also provide habitats for a range of aquatic invertebrates (Beaver 1983, 1985, Clarke & Kitching 1993). The majority of the macrofauna are dipterans, forming discreet communities which have proved useful in food web research. Beaver (1979) classified the organisms found in *Nepenthes* pitchers into three groups. Nepenthebiont species are those which live or develop only within the fluid of *Nepenthes* pitchers: they depend on pitchers for their survival. Nepenthephiles are those species which live or develop primarily in *Nepenthes* pitchers, but are occasionally found in other habitats as well. Nepenthexenes are not usually found in *Nepenthes* pitchers, but occasionally colonise them, for a variety of reasons (see Beaver 1983).

Borneo is the centre of diversity for *Nepenthes* and Beaver (1985) suggested that the pitcher communities there would also support the most species-rich and complex animal communities. Clarke & Kitching (1993) showed that this assumption is generally correct, but that the number of dipteran species present in pitchers varies from one *Nepenthes* species to another. Beaver (1983) provided a checklist of all organisms that are known to colonise *Nepenthes* pitchers, but most of the records for Borneo were based on previous taxonomic studies. In the course of performing research on the ecology of *Nepenthes bicalcarata* in Brunei, I examined more than 500 *N. bicalcarata* pitchers, thereby gaining the opportunity to substantiate many of the records of infaunal species collected from pitchers of this species. This short communication provides a revised checklist of the metazoan species collected during these studies.

MATERIALS AND METHODS

The contents of approximately 550 *N. bicalcarata* pitchers were examined between July 1989 and August 1990, from a number of locations in Brunei. Pitchers were removed intact from the host plants and taken to the laboratory for examination. The contents of the pitchers were examined under the stereomicroscope and the inhabitants identified. Where possible, larvae were reared through to adult stages by placing them in jars containing distilled water and pitcher fluid, incubated at room temperature (22°C). Authorities for metazoan species names are presented in Table 1.

RESULTS AND DISCUSSION

The revised list of metazoan species collected from *N. bicalcarata* pitchers is presented in Table 1. A total of 33 species were found, of which 28 were nepenthebionts, four were nepenthephiles and one was nepenthexene (although the status of some species has not been confirmed). The majority of species are dipterans, with mosquitoes comprising almost half of all species collected (13). More infaunal species have been collected from *N. bicalcarata* pitchers than from any other *Nepenthes* species and Clarke & Kitching (1993) showed that it also has the most complex *Nepenthes* food web.

No attempt has been made here to draw a food web for the complete *N. bicalcarata* community, as many species rarely (or never) coexist in the same pitcher. For instance, *Misumenops nepenthicola*, *Xenoplatyura* sp. and *Camponotus schmitzi* do not appear to co-exist, with the two former species only colonising pitchers when *C. schmitzi* is absent. Moreover, the three species of *Toxorhynchites* collected are rarely found in the same pitcher as the larvae are cannibals.

In contrast, up to three *Culex* species may co-exist in one pitcher and despite Beaver's observation that repeated colonisations of pitchers do not occur in *Nepenthes albomarginata* (Lobb) pitchers in Penang, several species colonise *N. bicalcarata* pitchers repeatedly (Clarke & Kitching 1993).

One species, the noctuid, *Eublemma radda*, was recorded by Beaver (1983) as having been collected from *N. bicalcarata* pitchers. In Brunei, *E. radda* primarily colonises pitchers of *N. mirabilis* (and sometimes *N. gracilis*) and was not found in *N. bicalcarata* pitchers in this study. However, it is possible that *E. radda* colonises *N. bicalcarata* very occasionally. In determining its ecological grouping (Table 1) it was classified as a nepenthebiont (as it requires *Nepenthes* pitchers in which to develop), but is very rare in *N. bicalcarata* pitchers. It is difficult to determine whether the two species of frogs collected are nepenthebiont or nepenthexene—more field observations are required.

Of all carnivorous plants, *N. bicalcarata* seems to have evolved the most complex and elaborate interactions with animals (see Clarke & Kitching 1995, Clarke 1997a). This list may be far from complete, as it only includes samples of pitchers collected from the Belait and

Table 1. List of metazoan taxa collected from *N. bicalcarata* pitchers in Brunei.

The ecological groupings are based on those of Beaver (1983), where B = nepenthebionts, P = nepenthephiles and X = nepenthexenes.
* Denotes species which were not identified with certainty.
† Denotes species attributed to *N. bicalcarata* by Beaver (1983) which were not found in *N. bicalcarata* pitchers in this study.

	Taxon	Family	Feeding strategy	Ecological Group
	Diptera			
1	*Polypedilum* (*Pentapedilum*) *convexum* Johannsen	Chironomidae	Detritivore	P
2	*Dasyhelea nepenthicola* Wirth & Beaver	Ceratopogonidae	Detritivore	B
3	*Aedes* (*Alanstonea*) *brevitibia* Edwards*	Culicidae	Detritivore	B?
4	*Armigeres* (*Armigeres*) sp.	Culicidae	Detritivore?	B?
5	*Culex* (*Lophocearomyia*) *coerulescens* Edwards	Culicidae	Detritivore	B
6	*Culex* (*L.*) *navalis* Edwards	Culicidae	Detritivore	B
7	*Culex* (*L.*) *hewetti* Edwards	Culicidae	Detritivore	B
8	*Culex* (*L.*) *eminentia* Leicester*	Culicidae	Detritivore	B
9	*Toxorhynchites* (*Toxorhynchites*) sp. 1	Culicidae	Predator	B?
10	*Toxorhynchites* (*Toxorhynchites*) sp. 2	Culicidae	Predator	B?
11	*Toxorhynchites* (*Toxorhynchites*) sp. 3	Culicidae	Predator	B?

12	*Tripteroides* (*Rachionotomyia*) *nepenthis* Edwards	Culicidae	Detritivore	B
13	*Tripteroides* (*R.*) *nepenthesimilis* Mattingly*	Culicidae	Detritivore	B
14	*Tripterioides* (*R.*) *tenax* Meijere*	Culicidae	Detritivore	B
15	*Uranotaenia* (*Pseudoficalbia*) *moultoni* Edwards	Culicidae	Detritivore	B
16	*Corethrella calathicola* Edwards	Chaoboridae	Predator	B
17	*Corethrella* sp. 1	Chaoboridae	Predator	X?
18	*Lestodiplosis* sp.	Cecidomyiidae	Predator	B
19	*Xenoplatyura* sp.	Mycetophilidae	Predator	B
20	*Megaselia campylonympha* Schmitz	Phoridae	Detritivore	B
21	*Nepenthosyrphus oudemansi* Meijere*	Syrphidae	Detritivore	B
22	*Wilhelmina nepenthicola* Villeneuve	Calliphoridae	Detritivore & predator	B
23	*Nepenthomyia malayana* Kurahashi & Beaver	Calliphoridae	Detritovore & predator	B
24	Calliphorid sp. 1	Calliphoridae	Detritovore & predator	B?

	Lepidoptera			
25	*Eublemma radda* Swinhoe†	Noctuidae	Herbivore	B
26	Lepidopteran sp.	?	Herbivore	B
	Hymenoptera			
27	*Camponotus* (*Colobopsis*) *schmitzi* Schuitemaker & Stärke	Formicidae	Detritivore & predator	B
28	Encyrtid sp.	Encyrtidae	Pupal parasitoid	B
	Aranae			
29	*Misumenops nepenthicola* Pocock	Thomisidae	Predator	B
	Acari			
30	*Zwickea nepenthesiana* Hirst	Anoetidae	Detritivore	B
	Brachyura			
31	*Geosesarma* sp.	Grapsidae	Detritivore	P?
	Anura			
32	*Philautus* sp.	?	N/A	P?
33	? sp.	?	Detritivore	P?

Tutong Districts of Brunei. Further collections from other populations of *N. bicalcarata* in Sabah and Sarawak may reveal further infaunal species.

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REFERENCES

Beaver, R. A. (1979) Fauna and foodwebs of pitcher plants in West Malaysia. *Malayan Nature Journal* 33: 1–10.

———— (1983) The communities living in *Nepenthes* pitcher plants: fauna and foodwebs. In: J. H. Frank & L. P. Lounibos (eds.) *Phytotelmata: terrestrial plants as hosts for aquatic insect communities*, pp. 129–159. Plexus Publishing, Marlton, New Jersey.

———— (1985) Geographical variation in food web structure in *Nepenthes* pitcher plants. *Ecological Entomology* 10: 241–248.

Clarke, C. M. & R.L. Kitching (1993) The metazoan food webs from six Bornean *Nepenthes* species. *Ecological Entomology* 18: 7–16.